An Updated Calibration Plan for the KamLAND Detector

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1 Introduction

At present, KamLAND detector calibration and monitoring with calibration sources is carried out according to the following scheme. On a weekly basis, a gamma source (usually Co–60) is deployed at a few positions along the z–axis. The data from these weekly deployments are promptly analyzed on–site to measure changes in energy and vertex reconstruction. These weekly data are also used to update the calibration tables used by event reconstruction in the US analysis. After any change to the detector, at least one gamma source is deployed to gauge the impact of the change; if the change is known to be significant, a combination of gamma and neutron sources, the US laser, and the Japan laser is deployed at multiple positions. The latter is a so–called full calibration. Until now, all full calibrations have been triggered by known changes in the detector hardware although in principle full calibrations could also be triggered by significant changes in detector response detected through the weekly deployments. Deployment of any source must be preceded by appropriate certification of the source and preparation of the source and deployment system according to well-defined procedures.

In the near future, some changes significantly impacting calibration will take place. One change is that personnel fully trained in the preparation of sources and operation of the deployment system will no longer be present full-time on the site. A second change is that the deployment system will be upgraded to allow calibration sources to be positioned off-axis. It should be noted that, as part of this upgrade, the motorized winch and associated controls presently used for z–axis deployments will be removed, and subsequent z–axis deployments will use one of the winches installed for off–axis deployments. The purpose of this note is to propose how detector calibration will continue with these changes in place.

We will make a distinction below between three types of source calibration. The first type of calibration is a so–called *routine calibration*. In such a calibration, a single source, which is already attached to the the z–axis deployment system, is deployed at a small number of positions. Only the controls for the glovebox purging system, gate valves, and winch motor have to be operated. The second type of calibration is the so–called *full z–axis calibration*. In this calibration, multiple sources (radioactive, laser, LED,...) are deployed at various positions on the z–axis. In this type of calibration, sources must be transferred into, and out of, the glovebox with appropriate measures taken to prepare the sources for introduction into the glovebox clean room. The third type of calibration is the *4π calibration*, in which various calibration sources are deployed off–axis.

The remainder of this note is organized as follows. First, we suggest the nominal frequency at which specific types of calibrations will be carried out. Second, we specify the basic procedures which we think must be followed in carrying out any source calibration. Third and finally, we propose collaborators to take responsibility for various calibration tasks.

2 Calibration Frequency

2.1 Routine calibration

Routine calibrations will be carried out periodically using the composite source (Ge–68/Co–60). The calibration frequency will be twice/month. The source will be positioned in turn near the bottom of the detector, the center of the detector, and near the top of the detector. Data from routine calibrations will be reconstructed and analyzed within three days of being acquired by the UA group.

At a minimum frequency of once/week, at least one day of normal data will be reconstructed on–site and the results promptly analyzed by the UA group to obtain information on detector stability between routine source deployments.

Why is twice/month chosen for the frequency of routine source deployments? First, based on experience, biweekly routine source deployments combined with weekly monitoring of normal data should suffice to account for variations in detector response outside of major hardware failure or changes. Although the degree to which the US analysis will use normal data for calibration remains to be seen, monitoring of normal data will at least be used to help define the intervals of validity for sets of calibration constants derived from routine source deployments and full calibrations. Second, should there be an occurrence (expected to be rare) of a a significant detector change between routine source deployments that cannot be recognized or understood from monitoring of normal data, no more than one half month of data will be lost. In the end, the determining consideration on routine source deployment frequency is the physics analyses: if these indicate that the source deployment frequency–or any other aspect of the calibration plan–is hindering achievement of KamLAND physics goals, the calibration procedure must be changed accordingly.

In the event there is a change to the detector hardware, e.g. a front–end electronics board swap, whose impact on detector stability is unknown, a routine calibration will be carried out within a few days after the change to gauge the magnitude of its effect.

2.2 Full z–axis calibration

A full z-axis calibration will be carried out whenever at least one of the following conditions occurs:

1. Time variations in the detector response which are not taken into account by the detector calibration result in a contribution to systematic uncertainties. A full z–axis calibration will be carried out when it is no longer possible, using routine source deployments and monitoring of normal data, to control this contribution to within (a) 0.5% for energy reconstruction or (b) 2 cm for vertex reconstruction inside the fiducial volume. This ensures that overall systematic uncertainties in energy reconstruction and vertex reconstruction will not be dominated by detector performance varying with time.

2. There is a change to the detector whose impact on event reconstruction is expected to be significant.

3. It has been 6 months since the previous full z–axis calibration or 4π calibration.

Concerning Condition 1, close communication must be maintained between (a) those carrying out the analysis of routine calibration data and normal data for monitoring purposes and (b) the analysis groups to estimate when the impact of uncertainties associated with time variations reaches the levels indicated for energy and vertex reconstruction.

2.3 4π calibration

A 4π calibration should be performed as soon as possible. We will be in a better position to estimate the required frequency of 4π calibrations once we have the experience of the initial 4π calibration, but it is expected that no more than two will be needed per year.

3 Procedures

Procedures followed in source calibration involve the *calibration committee*, *calibration coordinator*, *calibration liason*, and *calibration system operators*:

- The calibration group has delegated to the *calibration committee* final authority for all policies and procedures concerning detector calibration with sources. This includes certification of sources, maintenance of sources on–site, and deployment of sources.

- The *calibration coordinator* is responsible for planning source calibrations and seeing to it that they are executed in a timely way according to approved policies and procedures. It is the responsibility of the calibration coordinator to see to it that written and up–to–date documentation on calibration procedures exists in an easily accessible place and that checklists are drawn up for common calibration tasks and followed. The calibration coordinator is expected to maintain close communication with the analysis groups to see to it that the desired calibration data are collected and that these data are used in an timely and effective way. The calibration coordinator is nominated by the calibration committee and approved by the collaboration.

- The *calibration liason* is based at the experiment and acts as the representative of the calibration coordinator when the calibration coordinator is not based on–site. The on–site calibration liason represents the interests of calibration in scheduling meetings and monitors calibration activities on–site.

- The *calibration system operators* perform the source calibrations based on their expertise and level of training.

For any new source proposed for KamLAND calibration, its certification must be reviewed and approved in writing by the calibration committee before it can be brought to the site. Procedures for on–site storage and deployment of each source must be documented and followed.

Source calibration, whether it be a routine calibration, a full z–axis calibration, or a 4π calibration, can be performed only by calibration system operators with the appropriate level of training. Only collaborators certified by the calibration coordinator and approved by the calibration committee may participate as operators in source calibrations. Written and up–to–date documentation for each aspect of the calibration must be available to the operators, and the operators must follow the appropriate checklist. Documentation and training for the use of any new source or deployment system is ultimately the responsibility of the group which built it; such documentation and training is subject to the approval of the calibration coordinator.

Any source calibration must be approved by the calibration coordinator and communicated to the on–site KamLAND coordinators and calibration liason at least one day in advance of the proposed calibration in the case of a routine calibration and at least one week in advance of any other kind of calibration. The calibration committee must be informed of any calibration request. All source calibrations are subject to final approval by the on–site coordinators.

4 Responsibilities

We nominate the following persons and groups to accept the responsibilities described above. (All individuals nominated below have indicated their willingness to accept the proposed responsibilities.)

1. Herb Steiner and Jerry Busenitz to constitute the calibration committee.

2. Evgueni Yakushev to serve as calibration coordinator and Tim Classen to serve as deputy.

3. Kengo Nakamura to act as calibration liason in the absence of Evgueni Yakushev on–site.

4. Calibration system operators: Evgueni Yakushev and Tim Classen are fully trained in the use of the glovebox and z–axis system and the preparation of sources for deployment. For the forseeable future, they will maintain this level of training for full z–axis calibrations and will travel to the site to prepare for and carry out any full z–axis calibration. For complex sources such as the laser systems, it is assumed that, as in the past, source experts will work with the trained glovebox and deployment system operators to carry out the calibrations. For carrying out routine calibrations, Kengo Nakamura and Shuichiro Hatakeyama have been trained. In addition, the Tohoku group has provided two students, Koichi Ichimura and Kentaro Owada to carry out one routine calibration per month; these students have also been trained. One routine calibration each month will thus be carried out by either Ichimura–san or Owada–san and the other routine calibration each month will be carried out by either Shuichiro or Kengo. Routine calibrations that must be carried out at short notice will be the responsibility of the calibration liason. Every opportunity will be taken to train additional collaborators for routine calibrations to maintain an adequate pool of manpower as people leave the experiment or move on to other responsibilities.

5. The UA group will continue to be responsible for prompt analysis of routine deployment data. It will also assume responsibility to implement a program which takes normal data reconstructed on–site and and analyzes at least one day of data each week for the purpose of monitoring detector stability. Prompt reconstruction of all data on–site has been implemented by the Tohoku group. At the time of this writing, it is operating in test mode but is expected to changed to a regular shift duty within a few days. The UA group will define a basic set of global and semi–global quantities to be tracked by this program. Suggestions for additional quantities to be tracked will be solicited from the collaboration. The calibration coordinator will collect these suggestions and work with the calibration committee and analysis groups to organize the resources needed to define these additional quanitities and make effective use of the information gained by tracking these quantities.

5 Concluding Remarks

What we have mainly aimed to accomplish in this proposal is to identify manpower and outline tasks and procedures that will enable KamLAND to continue to carry out a successful detector calibration program despite changing circumstances in the near future. An important question that remains unanswered is how to maintain an adequate team of deployment operators beyond the next year. Evolution of the requirements for source deployments–and thus the demands on deployment manpower–will depend in part on the experience we gain using the new deployment system hardware and analyzing normal data for the purpose of monitoring detector stability.